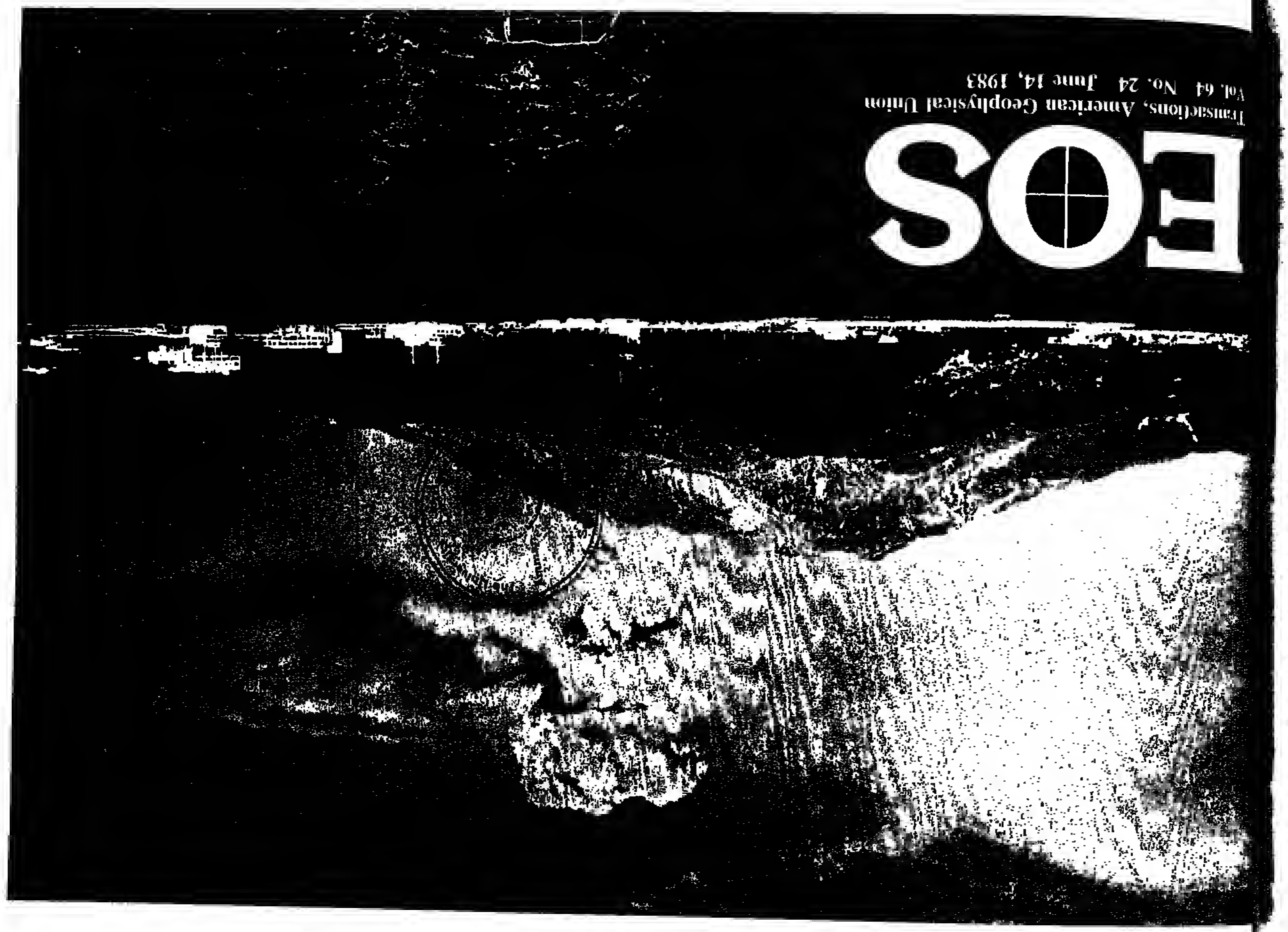

EOS, Transactions, American Geophysical Union   Vol. 64, No. 24, Pages 409 – 416   June 14,

Tectonophysics

5130 Heat Flow (Past Temperatures from Borehole Data)
DETERMINATION OF SURFACE TEMPERATURE HISTORY FROM BOREHOLE TEMPERATURE GRADIENTS
P. Y. Shen and A. E. Beck (Department of Geophysics, University of Western Ontario, London, Canada N6A 5B7)

The determination of surface temperature history from borehole temperature gradient profiles is commonly formulated as a linear least squares minimization problem. The surface temperature history is approximated by a series of intervals of constant temperature perturbation superimposed on a mean temperature, and the best solution obtained by systematically adjusting the number, duration and temperature of these intervals so as to minimize the least squares measure between the measured and calculated gradient profiles. However, this inversion problem is improperly posed. The gradient disturbances due to surface temperature perturbations in the series of time intervals are usually "almost linearly dependent". Thus the accuracy of a numerical solution is dictated by the level of random noise in the data and rounding errors in the computation. Using simulated data, we have systematically examined the effects of different noise levels, sampling ranges (maximum usable borehole depth) and sampling intervals (depth increment) on the resolution and time span of the derived surface temperature history. The method of orthogonal polynomials in curve fitting is also used in an attempt to improve the time span and resolution. The results, however, indicate that under realistic conditions, only about 4 intervals of temperature perturbation can be used to approximate the history of surface temperature variations. The major implications are: (1) Large time span and high resolution are mutually exclusive; for example, with a resolution of 100 years, the maximum time span would be about 400 years, whereas if a resolution of 50 years is desired, the maximum time span would be only 100 years. (2) In order to have a reasonable resolution, the epochs at which surface temperature changes took place must be known from independent information, because it is impossible to approximate adequately the surface temperature history with 4 arbitrarily chosen time intervals of constant temperature. (3) Any surface temperature changes which took place outside the time span of interest must be known and their effects removed from the gradient data; otherwise, interference from these temperature changes will lead to a distorted surface temperature history in the time span of interest.
J. Geophys. Res., Red, Paper 3B0751

5150 Plate Tectonics
EARLY TERTIARY SUBDUCTION ZONES AND HOTSPOTS
Donna M. Jurdy (Department of Geological Sciences, Northwestern University, Evanston, Illinois 60201)

Hotspots and subduction zones may control the position of the earth's rotation axis. Paleomagnetic reconstructions in the hotspot framework require a relative motion of about 10° between the hotspot reference frame and the earth's spin axis since the early Tertiary. If the viscosity of the mantle permits, a changing distribution of mass anomalies can control the position of the earth's rotation axis as it tracks the maximum principal axis of the perturbations. The present plate geometry should give the best indication of what features are associated with the controlling density anomalies. For the present, geoid anomalies indicate that subducting slabs are major mass contributions; removing these effects, a simpler "residual" geoid remains with highs strongly correlated with hotspot locations. Although neither the hotspots alone nor subducting slabs alone have maximum principal axes near the present pole, adding the contributions of the two gives a combined axis within a degree of the pole, suggesting that these two effects control the location of the spin axis. To establish whether changes in plate geometry could account for the observed polar motion, the locations of subduction zones are reconstructed in the hotspot framework for the early Tertiary, a time [illegible] but about 10° away in a location similar to the pole position required by paleomagnetic studies. This suggests that changes in subduction geometry may cause a shift in the position of the rotation pole, and furthermore, that inertia tensor effects may be the link between plate velocities and the spin axis. (Hotspots, subduction zone, spin axis, true polar wander).
J. Geophys. Res., Red, Paper 3B0701

5150 Plate Tectonics
BACKARC THRUSTING IN THE EASTERN SUNDA ARC, INDONESIA: A CONSEQUENCE OF ARC-CONTINENT COLLISION
E. A. Silver, (Earth Sciences, University of California, Santa Cruz, CA 95064), D. L. Reed, R. McCaffrey, and Y. S. Joyodiwiryo

The structure of the eastern Sunda backarc region is dominated by two large north-directed thrusts, the Wetar and Flores thrusts, and one or more minor thrusts, which may represent early stages of subduction polarity reversal of the arc. Gravity sliding or spreading are ruled out as primary driving mechanisms for the thrusts because slopes are similar in areas of thrusting and non-thrusting. Collision by the Australian continental margin is favored as the dominant mechanism, but slope stresses, forearc structure, and thermal weakening due to arc magmatism are seen as important factors facilitating the initiation of thrusting. (Collision tectonics, subduction, marine geophysics).
J. Geophys. Res., Red, Paper 3B0757

Volcanology

8699 Volcanology topics
THE ISOLATION OF STRATOSPHERIC TEMPERATURE CHANGE DUE TO THE EL CHICHON VOLCANIC ERUPTION FROM NON-VOLCANIC SIGNALS
R. S. Quiroz (Climate Analysis Center, NMC, NWS, NOAA, Washington, D. C. 20233)

To isolate the stratospheric temperature signal due to the eruption of El Chichón, Mexico (March 28–April 4, 1982) requires consideration of temperature changes of dynamic origin, changes related to the warming of the east equatorial Pacific ocean surface in 1982 (an El Niño event), and changes due to the quasi-biennial oscillation (QBO). Dynamically-produced changes in low latitudes associated with sudden warming episodes in the high-latitude stratosphere from January to April are accounted for, clearing the way for the diagnosis of temperature changes after April. From compositing of stratospheric temperature anomalies during past El Niño events, it is determined that temperature variation related to major sea surface temperature (SST) changes should be negligibly small in summer 1982, while important thereafter. For summer 1982 the remaining diagnostic problem involves estimating the temperature anomaly that should be due to the QBO and calculating the residual ascribable to the eruption. From a reconstruction of past QBO cycles and detailed inspection of the most recent cycles, as exhibited in station data near the equator and in zonally-averaged temperatures at 15–45°N (30 mb), estimates are obtained for QBO phase with latitude in 1982 and for temperature anomaly due to the QBO. Residual anomalies ascribed to the eruption amount to approximately 1.0–3.0°C between the equator and 35°N. This may be contrasted with total observed 30-mb anomaly up to approximately 5°C at stations such as Singapore (1°N). Further work for other altitudes and latitudes is needed, with proper accounting of non-volcanic signals. (Volcanic effects, temperature, stratosphere, climatology).
J. Geophys. Res., Green, Paper 3C0801

8699 Volcanology
VOLCANIC ERUPTIONS IN THE MEDITERRANEAN BEFORE AD 630 FROM WRITTEN AND ARCHAEOLOGICAL SOURCES
R. B. Stothers (Goddard Institute for Space Studies, NASA, 2880 Broadway, New York, New York, 10025), M. R. Rampino

Written and archaeological [illegible] from the [illegible] region have [illegible] searched for [illegible] the year AD 630, [illegible] two methods: direct observations, which give information about Mediterranean volcanoes, and indirect, atmospheric observations, which give at least the dates of any large explosive eruptions that occurred somewhere in the Northern Hemisphere. Seven or more very large [illegible] eruptions have been detected by these methods. Direct observations indicate great eruptions of Thera ([illegible] century BC), Etna (44 BC), and Vesuvius (217 BC, AD 472). Indirect observations imply great eruptions of Northern Hemisphere volcanoes in the years 217 BC, 44 BC, AD 472, AD 536, and AD 626. Some of the correlations with known Mediterranean eruptions are accidental. It is found that atmospheric veiling and cooling were quite marked for about a year after the eruptions of 44 BC, AD 472, AD 536, and AD 626 (the data are lacking for the other eruptions). If the [illegible] eruption was a very distant one (Rabaul, New Britain), it may have been the most explosive in recorded history. There is independent evidence of the sizes of the eruptions that took place in these years: at least [illegible] of them coincide with the strongest acidity signals in Greenland ice for this period. In the case of the smaller eruptions, reliable (though necessarily incomplete) chronologies are presented for Etna, Vesuvius, and the other active Mediterranean volcanoes. Full documentation from the original sources is provided throughout. (Volcanic eruptions, dry fogs, Mediterranean, historical records).
J. Geophys. Res., Red, Paper 3B0844

Early Experience of the SAO Satellite-Tracking Program

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When Fred L. Whipple of Harvard University assumed the directorship of the Smithsonian Astrophysical Observatory (SAO) in mid-1955, he proposed to the National Academy of Sciences and the National Science Foundation that the observatory be given responsibility for optical tracking of satellites during the IGY of 1957–1958. Several countries had expressed their intentions to launch satellites during the 18-month period to support research in ionospheric and upper atmospheric physics, including the effects of solar flares and solar radiation, and in geodesy and geophysics. On the basis of his experience at the Harvard College observatory with the Super-Schmidt cameras for meteor photography, Whipple was confident that optical tracking could provide a powerful means of monitoring satellite positions. The proposal was accepted in late 1955, and it was assumed that the total observing program would last only 18 months and would involve only a few satellites.

By early 1956, Whipple, with the assistance of J. Allen Hynek, had designed a program to determine the position of satellites illuminated in twilight periods by use of a network of 10–12 large aperture cameras based on the model of the Super-Schmidt. They also specified the requirements for communications and computations, as well as the need for a worldwide network of visual observers who would make preliminary observations to assist the large cameras in satellite acquisition. This volunteer network, later to be called Moonwatch, ended up playing a far larger role than was originally projected.

The optics of the special tracking camera were designed by James Baker of Harvard. Based on the specifications proposed for the Vanguard satellite, Baker designed an *f*/1 camera with 20-inch-diameter aperture, a curved focal plane, and an elaborate three-element corrector cell (see Figure 1). The mount and drive mechanism of the camera were designed by Joseph Nunn Associates. The camera, although it proved to be far more complicated, heavy, and costly than was originally anticipated, is a tribute to its designers. Many years later, the camera was still considered to be a formidable instrument of optimum design. The contract for the construction of the camera optics was awarded to Perkin-Elmer, and the contract for fabrication was given to Boller and Chivens in the autumn of 1956. The logistics of manufacturing what was to be called the "Baker-Nunn camera" were formidable. The camera was a new design. Twelve units were built concurrently. No prototype and no real testing were planned. The optics were fabricated on the east coast, the mechanics on the west coast. Plans called for the cameras to be assembled in Pasadena, California, with each shipped to its site as it was completed. Finally, the entire network was to be operational during the IGY, which was to start July 1, 1957.

While the cameras were being designed and built, the process of site selection was under way. The Vanguard satellite, which was considered to be the prime candidate for tracking, was to be launched at a low inclination. Thus, most station sites were selected to provide low latitude coverage around the world, with a few sites at slightly higher latitudes to provide enhanced geometry for geodetic research. Other site requirements included good weather, good horizons, and reasonably good accessibility for the receipt and transmission of data, equipment, and personnel. The final network is shown in Figure 2. Network staffing was arranged to suit local conditions: Some stations were manned solely by U.S. citizens, some by foreign nationals, and some by mixed crews. SAO developed the requirements for each site from the building design to the tools necessary for operation, although the basic plan was quite simple: a building to house the tracking camera and electronics and an office for administrative and data reduction functions.

Meanwhile, the amateur network, Moonwatch, was being rapidly organized with the help of astronomers worldwide. Observers were to use binoculars, or small telescopes, and stop watches to determine rough satellite positions, which would be radioed or telephoned to Cambridge, Mass., for retransmission to the camera stations as refined orbital predictions. Moonwatch team members were expected to furnish their own equipment; but SAO provided the design for building an inexpensive monoscope. In the end, Moonwatch evolved into two networks: a large network of observers using small telescopes capable of tracking objects to 7th–9th magnitude, and a smaller network of observers using larger telescopes capable of acquiring fainter objects. (This latter group would play a vital role later in the recovery of "lost" satellites.) By the summer of 1957, 80 active teams had been organized in the United States, with a similar number overseas. During that summer, simulation tests, using lights on aircraft, were conducted over a number of sites in the United States to check operational procedures and observer response. The U.S. Air Force played a very important role in the organization and setup of Moonwatch, and this close relationship and support continued through the subsequent operational years of the network.

Staff recruitment for the Baker-Nunn camera network began in early 1957. The observatory looked for candidates who were eager and enthusiastic as well as responsible and versatile. It got pioneers: do-it-yourself individuals who could devise and implement a means to do any job. These people really built the network, first in the field and later in Cambridge, when many returned to help in the development and evolution of the headquarters operation.

Through marathon sessions at both Perkin-Elmer and Boller and Chivens, the first Baker-Nunn camera was completed on September 30, 1957, and was set up outside the plant in Pasadena for star tests (see Figure 3). From photographs taken October 2, it appeared that the camera was functioning, but some minor modifications and adjustments were necessary. It was estimated that this work would require about 2 weeks.

Thus, when Sputnik 1 was launched October 4, 1957, the first Baker-Nunn camera was in Pasadena, still in need of work. Moreover, communications facilities had yet to be established at SAO headquarters, and the orbital software was still being debugged. Fortunately, Moonwatch was operational. The first optical observations came from the Geophysical Institute in Alaska on October 4 and 5. The first confirmed Moonwatch observations also came from Alaska on October 8 and then from a Connecticut team on October 10. These, and subsequent Moonwatch observations, were used to refine predictions on a day-by-day (and even hour-by-hour) basis for the computations groups at SAO.

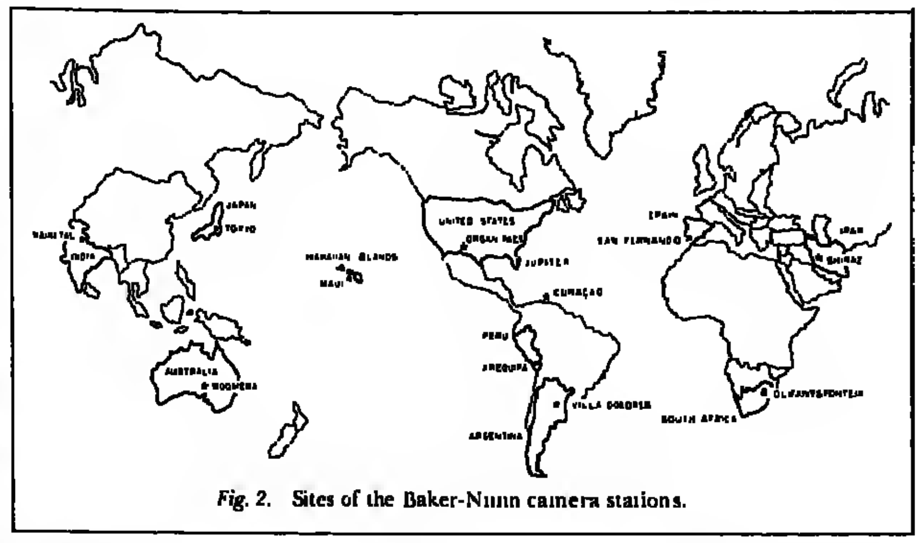

Fig. 2. Sites of the Baker-Nunn camera stations.

The visibility for Sputnik over Pasadena was poor in early October, so the Baker-Nunn Camera was disassembled and modified. It was back outside by mid-month; on October 17, the first photographs of Sputnik were taken (see Figure 4). From these photographs, it became evident that the tracking procedures required considerable improvement; although many frames had been taken, images appeared on only a few. (The camera actually photographed Sputnik's orbiting rocket body. In fact, it appears now that no western observer ever photographed the first Sputnik.) The camera remained at Pasadena for 3 weeks while tracking procedures were modified; it was then shipped to the first network tracking station at Las Cruces, New Mexico.

On November 3, the Russians launched Sputnik 2. To supplement the network on an interim basis, Super-Schmidt cameras from the Harvard Meteor Project were sent to Argentina and Hawaii to support tracking activities.

One of the biggest surprises and the first scientific discovery produced by tracking the Sputnik satellites was the large effect of air drag on orbiting bodies. The air density at orbital altitudes proved to be considerably larger than was expected. In addition, since it had been anticipated that the first satellite would be the U.S. Navy Vanguard, with an orbit much higher than Sputnik, the orbital software had made no accommodation for this air drag. As a result, early orbital predictions were often 5–10 min off, and the observers had to use elaborate search techniques to find the satellites. The early predictions thus relied heavily on Moonwatch visual observations, and, on some occasions, direct telephone contact between the Las Cruces Baker-Nunn camera and Moonwatch stations was established to produce updates in real time. By early 1958, however, predictions had improved considerably through the work of Luigi Jacchia, who developed models of atmospheric drag. (Jacchia used the same technique to predict accurately the demise of Sputnik 2 in April 1958.)

When the first U.S. satellite (Explorer 1, as it turned out, rather than Vanguard) was launched in January 31, 1958, Moonwatch observations were made almost immediately. Baker-Nunn observations were provided by the new station in South Africa by mid-March. As the other cameras were completed, they were shipped immediately to the field stations by U.S. Air Force MATS flights. The schedule of deployment and dates of first satellite observations are shown in Table 1. By mid-1958, all 12 cameras were in operation.

Because of the rush to field the cameras and crews, insufficient time was devoted to many of the observational, timing, and data reduction techniques. As a result, each station, and in some cases each observer, developed individual and innovative methods. Some were very good; some were less so. These differences in technique often led to difficulties in correlating data from one station to another. Another major problem was the lack of a standard star chart. Star positions were available in tabular form, and some observers memorized portions of the sky. But it was not uncommon to take 6–10 hours to identify star backgrounds for an evening's observations. However, by late 1958, standardized operating procedures had been established for the field stations, and extensive communications, computations, and photoreduction facilities had been set up at SAO. With the new Mann X-Y measuring machines, satellite positions could be determined to 1–2 arcseconds, an accuracy compatible with 10 m determination of station position. Moonwatch continued to play a very fundamental role in the network; 230 teams had already been established with over 3000 successful observations.

The IGY had assumed an 18-month program with only a few satellites. Yet, by the end of the IGY, there were already 11 satellites in orbit, and it was recognized that the international space program was just beginning. In July 1958, NASA was formed to take over responsibility for what was obviously going to be a long-term national program. Consequently, following the IGY, sponsorship of SAO's Satellite-Tracking Program was assumed by NASA.

SAO also recognized early that the space program would evolve rapidly and that the rapid distribution of information on events and scientific research was essential. The observatory instituted the *SAO Special Report Series* as part of its overall program, with the first report, "Preliminary Orbit Information for U.S.S.R. Satellites 1957 Alpha 1 and Alpha 2," issued October 14, just 10 days after the Sputnik launch. Over the next five years, more than 100 reports were issued on the results of optical satellite tracking including models of atmospheric density and its variations with solar activity, geopotential modeling, atmospheric and ionospheric influences on radio and optical propagation, satellite dynamics, and celestial mechanics.

As the Space Age progressed, the Baker-Nunn cameras also demonstrated their full design capabilities: Vanguard 1, a 6-inch diameter sphere, was photographed at a range of 2400 miles; Explorers 6 and 12 were photographed at ranges of 14,000 and 16,000 miles, respectively. In addition to satellites, the camera was also used to observe comets, flare stars, artificially injected ion clouds, upper stage rocket firings, and gas dumps in space.

By the early 1960s, network operations had become more systematic and routine. Manuals and procedures were in use, and all stations provided data on a uniform basis. Star charts and improved geodetic models for orbit analysis were available, and many of the early equipment problems had been solved. Improved calibration procedures were available for photoreduction, together with more efficient methods of cataloging observations. Long arc photography techniques had been developed, and simultaneous observation programs to measure baselines were introduced with the launch of the ANNA 1B satellite with flashing lights in 1962. The result was a steady improvement in data yield and efficiency (see Table 2). By the mid-1960s, the Photoreduction section of SAO was providing more than 50,000 precise positions per year. Moonwatch continued to be very active through the decade, with over 100,000 observations acquired by 1967. Although Moonwatch's role in producing predictions for the Baker-Nunn cameras had diminished somewhat, the network played an important role

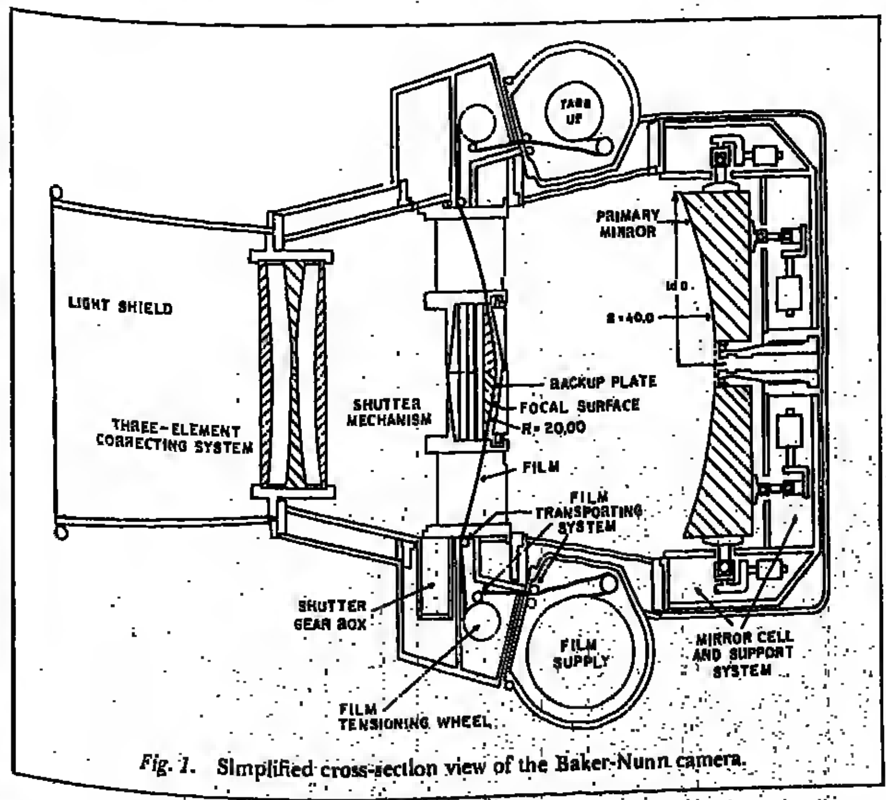

Fig. 1. Simplified cross-section view of the Baker-Nunn camera.

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[1] Presented at the AGU Fall Meeting, Reviews on Geodesy During the International Year, December 9, 1982.

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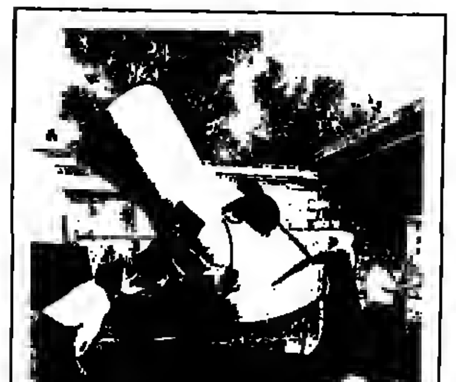

Fig. 3. The first Baker-Nunn camera set up at Boller and Chivens.

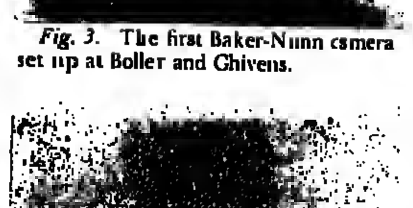

Fig. 4. First Baker-Nunn film of Sputnik 1.

in the acquisition of "lost" satellites and in providing specialized tracking for atmospheric studies and long period perturbations. (The Moonwatch network would continue to operate on a limited basis until 1975 when it was disbanded.)

The scientific contributions of the SAO Satellite Tracking Program also became apparent in the 1960s. The first "Standard Atmosphere," relying on large amounts of optical tracking data, was published in 1964. In 1966, the First "Smithsonian Standard Earth" provided a geopotential model of the planet, as well as a grid of satellite-determined station positions, and a discussion on the geodetic prospects for the future. These and similar models represented both the culmination of work that had begun during the IGY and the precursor of future research in satellite geodesy, geophysics, and upper atmospheric physics. The original goal of 10-m station positions at the time of the IGY has evolved, 25 years later, into a goal of 1 cm.

The Baker-Nunn cameras were gradually replaced by laser ranging systems in the 1970s, as SAO's mission of operational tracking changed to the support of scientific programs, particularly in earth dynamics. As the original stations were relocated to provide additional geodetic coverage, many of the cameras were decommissioned, and have since been donated to university and research organizations for continued scientific use. Appropriately, the first Baker-Nunn, which had photographed the Sputnik 1 rocket body from a machine shop yard in Pasadena and later saw service in New Mexico and Arizona, was officially transferred in 1980 to the National Air and Space Museum to become part of the collections marking the history of the early Space Age.

Acknowledgments. The author acknowledges his debt to *Trackers of the Skies* by E. Nelson Hayes (published by H. A. Doyle, Cambridge, Mass., 1968) for much of the early history of the SAO Satellite Tracking program recounted in this paper. The Smithsonian Astrophysical Observatory and the Harvard College Observatory are members of the Center for Astrophysics.

TABLE 1. Shipping Schedule of Baker-Nunn Cameras and First Successful Observations

Station	Date Camera Shipped	Date of First Observation	Object Photographed
New Mexico	November 2, 1957	November 26, 1957	1957 α1
South Africa	February 3, 1958	March 18, 1958	1958 alpha
Australia	February 22, 1958	March 11, 1958	1957 beta
Spain	March 2, 1958	March 18, 1958	1957 beta
Japan	March 20, 1958	April 5, 1958	1958 alpha
India	March 30, 1958	August 29, 1958	1958 δ1
Peru	April 8, 1958	July 4, 1958	1958 alpha
Iran	May 1, 1958	May 20, 1958	1958 δ1
Curaçao	May 5, 1958	June 22, 1958	1958 alpha
Florida	May 8, 1958	June 10, 1958	1958 δ2
Argentina	May 15, 1958	July 10, 1958	1958 δ2
Hawaii	May 28, 1958	July 4, 1958	1958 alpha

TABLE 2. Baker-Nunn Camera Predictions and Observations 1959–1967

	Predictions	Observations	Percentage of Predictions Observed
Year			
1959	22,463	6,524	29
1960	32,491	12,249	32
1961	61,632	19,520	40
1962	70,379	27,257	40
1963	82,734	23,895	45
1964	99,847	45,196	43
1965	130,331	61,075	47
1966	143,362	70,829	49
1967	126,514	56,315	45
Totals	747,290	316,336	42

News

GALE

A cooperative research project to study winter cyclonic development on the east coast of the United States is being planned by an informal consortium of universities and federal research laboratories. Known by the acronym GALE (Genesis of Atlantic Lows Experiment), the project is designed to provide detailed information on the role of air-sea interaction, boundary layer, and mesoscale processes in cyclogenesis and frontogenesis off the Carolina coast.

Rapid cyclogenesis off the Carolina coast often leads to severe weather in the heavily populated northeast corridor. Recent examples include the Presidents' Day snowstorm of February 18–19, 1979, which deposited 60 cm of snow on the Middle Atlantic States; the April 6–7, 1982, snowstorm and windstorm in which more than 50 people lost their lives; and the February 11–12, 1983, blizzard that paralyzed the northeast with record-breaking snowfall and freezing rain that caused 70 deaths. It is hoped that the detailed studies to be carried out in GALE will help improve the forecasting of such east coast cyclones.

Four university research teams have joined together in proposing the "core" research effort for GALE. They are the State University of New York at Albany (SUNY), Drexel University, North Carolina State University (NCSU), and the University of Washington (UW). Support for the core research effort has been requested from the Atmospheric Sciences Division of the National Science Foundation (NSF). Researchers from the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) will also participate in the core effort. Requests have been made to the National Center for Atmospheric Research (NCAR), NOAA, and NASA for facilities and personnel support.

The proposed core research effort for GALE calls for a 4-year program, centered around a 2-month field project from January 15 to March 15, 1985. Field facilities will be deployed over an approximately 2.5 × 10⁵ km² area, extending from Savannah in the south to Wallops Island in the north and from Greensboro in the west to about 200 km off the Carolina coast to the east. Proposed field facilities include specialized satellite coverage, a dense mesonetwork of ground stations, augmentation of the National Weather Service (NWS) rawinsonde network, tethered and free balloons, meteorological towers, digitization of the NWS radars from Florida to New York, four Doppler radars, several research aircraft, microwave and infrared radiometers, additional meteorological buoys and a research ship off the Carolina coast, and a lightning detection system from Georgia to Maine.

Overall scientific guidance for GALE is the responsibility of the Scientific Steering Committee (SSC). The members of this committee are Peter V. Hobbs (UW), chairman; L. F. Bosart (SUNY), vice chairman; S. P. S. Arya (NCSU); D. Atlas (NASA/Goddard); D. A. Barber (NCSU); W. Bonner (NOAA/NMC); D. J. Perkey (Drexel); and R. J. Serafin (NCAR). Ex officio members are R. A. Dirks (NSF), P. H. Herzegh (NCAR), and C. W. Kreitzberg (Drexel).

It is anticipated that other scientists will wish to take advantage of the opportunities afforded by the research facilities to be mounted for GALE and the unique data base that should accrue from this project. Those wishing to participate in GALE are invited to submit, by October 1, 1983, to the chairman or vice chairman of the GALE SSG a brief statement of interest (Peter V. Hobbs, AK-40, University of Washington, Seattle, WA 98195; Lance F. Bosart, Department of Atmospheric Science ES-227, State University of New York at Albany, 1400 Washington Avenue, Albany, NY 12222). The statement should outline the research objectives, instrumentation and/or data requirements, field operational plans, and the anticipated source and level of financial support. These statements will be used to coordinate further planning for GALE.

This news item was contributed by Peter V. Hobbs, chairman of GALE.

Gravitational Field Theories Combined

Einstein's gravitation theory has been beset with problems for a long time. These problems are related to the extension of the theory to outer space. All measurements to test the theory have been done on or near earth, but a number of convincing theoretical arguments have been made to suggest that the tests do not adequately explain effects in space beyond the solar system. It seems that an additional, supplementary field may be required in certain domains of outer space.

In a new gravitational theory, which combines Einstein's main theory with modifications to explain supplementary field requirements, the Rumanian physicist, M. Borneas has developed a novel approach. In "On a possible new theory of gravitation" (*Naturwissenschaften, 70,* 1983), Borneas proposes generalized equations that explain why, for example, experiments done in our solar system satisfy Einstein's theory, whereas in certain domains of space, such results would not satisfy the modified theory.

Borneas notes that the main Einsteinian fields can be derived from the action principle, as follows from the space-time differential equation:

$$\delta\int d \times g^{1/2} (R \times Lm) = 0$$

where R is defined as the scalar curvature of space-time; the LM is the matter Lagrangian. More recent requirements include the addition of a supplementary scalar field to this field. The approach in the new theory is to define a scalar field such that its contribution varies in an acceptable way. The result would have the supplementary field approach zero in this solar system. In Lagrangian form the supplementary gravitational field is represented simply:

$$Ls = \epsilon f_A \Gamma^A \text{ (summation convention)}$$

The ϵ term is the factor related to circumstances in space and can vary from zero. Borneas accomplishes this by relating ϵ to the metric g_{ij} and its variations, as follows:

$$\epsilon = i\,(V_{\mu}{}' + \Gamma_{\mu\nu}{}^{\nu} V^{\mu})$$

in which $\Gamma_{\mu\nu}{}^{\nu}$ is the contracted Christoffel symbol, used here to build the appropriate scalar dependence. The ν' is defined as a very small imaginary vector (not a measurable field), ϵ being a real scalar that depends on the metric.

Borneas' equation thus becomes

$$\delta g \int dx + g^{1/2} (R + LM + Ls) = 0$$

He notes the value of the Christoffel symbol as $(\Gamma_{\mu}{}')0$ when it has the maximum value in the solar system. Thus it follows that

$$\epsilon = -i\,|V_{\mu}{}' + (\Gamma_{\mu\nu}{}')_0 V^{\mu}| = 0$$

resulting in the supplementary field, under those conditions, approaching zero. These are the conditions under which all solar system experiments have been conducted.

If, however, the value of the Christoffel symbol in the same frame of reference is larger, say, in some other domain of space, ϵ becomes important. For smaller values within the solar system, but in a different reference frame, ϵ still has the same value.

These ideas are in agreement with experimental results that have been made to test Einstein's theory. Borneas notes the properties of the supplementary field as follows: it is possible that some effects result from a rapid variation of the metric in some domains of space (perhaps under conditions of gravitational collapse or due to quasar or cosmic catastrophes).

This new theory, though untestable directly, may produce indirect effects that can be observed.—*PMB*

Shuttle Woes

Shortages of spare parts and delays caused by unexpected repairs are most likely to interfere with the National Aeronautics and Space Administration's (NASA) goal of 30 annual space shuttle launches by 1990, according to a National Research Council panel. NASA's chances of meeting the goal of 30 launches per year are "impossible or highly improbable" with four orbiters and "marginal" with a five-orbiter fleet, the panel says. Furthermore, the lack of spare parts or delays caused by unexpected repairs are more likely to limit shuttle launches than will shortages of major units such as external tanks or solid rocket boosters.

Four orbiters could support between 17 and 25 annual launches by about 1990; five orbiters could support between 22 and 31, according to the Panel to Assess Constraints on Space Shuttle Launch Rates, chaired by William T. Hamilton, a consultant to the Boeing Co. and retired vice president and chief scientist of the Boeing Military Airplane Co. NASA's plans, however, call for 24 space shuttle launches per year in 1988, 30 in 1990, and 40 in 1992.

According to the panel's report, "Assessment of Constraints on Space Shuttle Launch Rates," the external tank, which carries liquid hydrogen and oxygen fuel for the orbiter's three main engines, is "the only major component of the [space shuttle system] for which firm planning is in place to attain levels of 24, 30, and 40 flights per year."

"The possibility of major damage to the shuttle and to ground test facilities from engine component failures is high," the panel said, because the shuttle's main engines include such advanced, state-of-the-art systems. Stresses on the orbiter structure come "much closer to design limits than does a normal flight for commercial or military aircraft."

Congress asked the panel to examine the constraints on the frequency of shuttle missions after NASA had requested that funds be diverted from its research and development budget to a new production facility for the shuttle's expendable external fuel tanks. NASA funded the study.

Ice, Oceans, and Isotopes

New ideas on high rates of glaciation and deglaciation have suggested changes in currently accepted ideas about the glacial periods and their causes. At the same time, new studies are being done on deep ocean isotope fractionation phenomena. These phenomena are similar to those defining glacial periods, and the new studies have raised questions about paleoclimate analysis for the time span just preceding the glaciers.

The broad variety of explanations for the glacial epochs in the northern hemisphere beginning about 15 million years ago and the lack of sufficient data on the epochs appear to be the result of low precision in correlation between land and ocean methods. Among the many correlations are factors related to the oxygen isotope temperature scale obtained from analysis of marine invertebrate specimens.

Isotope fractionation is related to deep ocean temperature, which in turn is related to ice volume. There are radioisotope daughter product ages associated with the fossils, so a scheme of geologic time, fractionation, and temperature/ice volume can be brought into conjunction with terrestrial glacial data and even with global climate trends and the astronomical events responsible for them. This pattern of analysis, described by C. Emiliani almost 30 years ago (*Journal of Geology, 63,* 538, 1955) is still being widely followed; but the new data on isotope fractionation processes and on paleoclimates are providing a few new twists in interpreting the many areas of the scheme that are characterized by uncertainty.

At least one glaciation period was described as a "pulse" by W. F. Ruddiman and A. McIntyre with rapid rise-times of ice accumulation (*Geological Society of America Bulletin, 93,* 1273, 1982). J. T. Andrews recently discussed these results as providing "strong support for the Milankovitch hypothesis according to which northern hemisphere glaciation should coincide with insolation minima—periods when the sun is at its furthest from the earth" (*Nature, 303,* 21, 1983). Meanwhile, recent mathematical modeling of carbonate recrystallization in the oceans by J. Killingley (*Nature, 301,* 594, 1983) suggests that isotope fractionation observations in some preglacial rocks could conceivably be the result of chemical alteration of the sediments instead of the isotopic shifts being in response to changes in ocean water temperature. R. A. Kerr quotes Killingley as saying, "I don't believe it explains all of the observed trends, but the model is so similar, we have to be careful. It's a warning flag" (*Science, 220,* 807, 1983).

Evidence for the occurrence of rapid, severe pulses in glaciation in the northern hemisphere is based on benthic fossil age and isotopic measurement, which correlate with insolation minima 231,000 years ago. The insolation minima were on the order of -30 to -40 Δ Langleys (from 1950 values), at latitudes of 10°N, 65°N, and 80°N, all centered at the same age. These minima bisect the interglacial stage 7; thus it is called 7b. Right at substage 7b lies a volcanic ash layer whose 230,000 year age is equivalent to the minimum. The only problem with this correlation, pointed out by Andrews, is that marine isotope state 7 is thought to be a nonglacial period. It is noted, however, that the isotope-temperature-ice growth relation could be uncertain by ±50%. The cooling phenomena could be at the bottom-water level instead of at the glacier.

Dating techniques of the terrestrial glaciological record are not accurate enough to confirm the ocean-bottom data. Dating of sea level fluctuations could, perhaps, confirm the volumes of ice needed to support rapid glaciation pulses. Apparently, the suggestion is there, but the complexity of the fluctuations and the required rapidity of the glaciation have caused difficulties. The ice-growth events are not yet correlated with sea level changes.

The problems of dissolution and recrystallization of benthic forms before consolidation of the sediments in the deep oceans—which would affect isotope fractionation—are probably restricted to much older rocks than would be relevant to the glacial epochs. The isotope data in question are used to trace the record of the climate in the time interval 65–15 million years ago. The techniques of interpreting isotope data as being an indication of climate changes could be complicated by alteration of the sediments if isotopes are exchanged with seawater. Killingley's simulated recrystallization processes can produce isotope effects of proportions similar to those observed. The problem of recognizing the degree of alteration in specimens, though, may not be real.—*PMB*

Polar News

Cores of ocean-bottom sediments and other geological samples collected near and in Antarctica are available for study by qualified scientists, according to the National Science Foundation (NSF). Available are 12,900 m of piston, trigger, and phleger cores from the southern oceans; 4,200 kg of grabbed, trawled, and dredged rock specimens from 600 ship stations; and 1,150 m of drilled cores from the ice-free valleys of southern Victoria Land. Most specimens were obtained in the last 21 years.

Scientists need not have an NSF grant to obtain samples, but proposals for grant support of such studies will be considered by NSF's U.S. Antarctic Research program. For additional information, contact Dennis Cassidy, Curator, Antarctic Marine Geology Research Facility and Core Library, Department of Geology, Florida State University, Tallahassee, FL 32306 (telephone: 904-644-2407).

The list of the 161 research projects supported by NSF in fiscal 1982 at the other pole has been published. *Arctic Research Fiscal Year 1982* may be obtained from Charles Myers, Division of Polar Programs, National Science Foundation, 1800 G Street, N.W., Washington, DC 20550 (telephone: 202-357-7934).

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Cover. This geoid is the equipotential surface in the terrestrial gravity field that coincides with undisturbed mean sea level extended through the continents. The direction of gravity is perpendicular to the geoid at every point. The geoid is the surface of reference for geodetic levelling and astronomical observations. The Air Force Geophysics Laboratory Geodesy and Gravity Branch has accurately determined the shape of the geoid by using SEASAT satellite altimetry and other data derived from satellite tracking and surface gravimetry. This map shows a highly detailed 1° × 1° oceanic geoid derived from interpolation of SEASAT data. The contour interval is 5 m. (Photo courtesy of Donald Eckhardt, Air Force Geophysics Laboratory, Bedford, Mass.)

Books

Analyzing Natural Systems: Analysis for Regional Residuals—Environmental Quality Management

D. J. Basta and B. T. Bower (Eds.), Resources for the Future, Washington, D. C., xv + 546 pp., 1982.

Reviewed by Peter P. Rogers

A colleague who is the head of a water planning agency in a large neighboring county and who was under some pressure to use the types of models discussed in this book told me, "You can either guess the input to the models or you can guess the results. As an engineer with long experience with the water systems that I manage I would rather guess the results because I have a feel for what is likely. If I use the models based upon very imperfect data my experience is completely ignored, and who knows what the results really mean."

Basta, Bower, and their coauthors have done an excellent job in summarizing the state of the art of the models available for analyzing natural systems with an eye to environmental quality management. What a sorry tale they tell. In the terrestrial, the aquatic, and the atmospheric environment the message is the same; the mathematical formulations have run ahead of the conceptual understanding of the underlying processes and the measurement of data on these processes.

How this situation has come about is in itself an interesting story and one that should be explored more fully. What were the scientific underpinnings of the National Environmental Protection Act that allowed it to demand scientific analyses that were not possible at that time, or maybe never possible? Why did the scientific community not refuse to collaborate with requests that were patently impossible? The legal or the administrative requirement to carry out modeling studies did, however, seduce many engineers and scientists, this reviewer included, to try to do the best they could under the situation. In retrospect, this was a great error because we have allowed air and surface water models to be adopted and be required (in some cases, models are even mentioned by name in the *Federal Register*), without regard to measuring the ambient environment before predicting effects of man-induced impacts. The engineering and the scientific community are expected to perform analyses and prediction without a proper scientific base.

The book that is the subject of this review is a Research Paper from Resources for the Future (RFF). Research Papers are studies and conference papers made available by RFF from the author's typescripts and are intended to achieve rapid dissemination of the work for wide review and comment. It may be unfair to comment upon the speediness of the report production, but no work later than 1978 is seriously discussed in the book.

This book represents a serious attempt by a group of seven leading practitioners to present the state of the art of the models for environmental quality management in natural systems. This is a very ambitious task for one volume. A major problem is defining the audience. According to the preface

> The primary audience for the volume consists of staff members of governmental agencies, enterprises, and consulting firms, the individuals who actually make the analyses to develop strategies for achieving and maintaining ambient environmental quality. The audience is a varied one, ranging from generalist planners with little or no mathematical skills to biologists, ecologists, environmental and sanitary engineers, computer programers, chemists, economists, political scientists, sociologists, to experienced natural systems modelers. Another component of this audience is composed of students and teachers concerned, in one way or another, with assessing the impacts of public and private decisions on natural systems.

Such an audience cannot be addressed successfully in one volume. Only an expert can appreciate the comments given on the applicability of the models; however, an expert would already know these points, and then the treatment is superfluous. The major potential use of the book will be to educate the experts in the areas of terrestrial, aquatic, and atmospheric assessment about the kinds of models available. Groundwater models, however, are not included. It could also serve as a useful reader in upper level undergraduate courses in environmental sciences, provided the instructor is able to provide evaluative material.

After a general and jargon-laden introduction (chapter 1) by Bower and Basta about modeling philosophy, the book moves to a second introduction (chapter 2) by Basta and Moreau, this time about natural systems models. The "new-speak" continues, NSM's, REQM's, and AEQ's abound in this chapter.

While the section "Calibration and Verification" seems to say the right things in the right order, the authors do not appear to be unduly concerned when they report on the typical lack of verification and validation natural systems models receive. What the authors report at this point should have led them to conclude, and print in block capitals in red, "These models do not predict actual likely occurrences of ambient concentrations. It is hazardous to use them directly for practical applications or policy decisions." At this point, the reader gets the impression that the *Titanic* sank, and nobody noticed, least of all the authors, who continue to row quietly for the other side of the Atlantic.

The third chapter is a review of models for residual generation and discharge from urban and nonurban land surfaces by Huber and Heany, who reviewed the literature and reported 73 models known to have been used in this area of environmental modelling. From these 73 they chose 14 models for detailed analysis. The chapter is well written, and the material is easy to follow. Again, however, the chapter is weak on evaluation. A complex matrix listing of available models is given which is supposed to help the reader choose which model to use. However, guidance on model selection in given situations and expected reliability would have been a welcome addition.

In chapter 4, Hinson and Basta give an exhaustive review of the "surface receiving water bodies" models. They review 27 models from the literature and use a matrix format similar to Huber and Heany for aiding in the selection of a model. However, after reading this chapter, one is left with no impression as to how well the different models actually mimic reality.

The last chapter, by Muschett on air pollution modeling, is extremely well written and quite sophisticated in its treatment. Muschett lists 97 models and claims that there are 33 operational ones. He discusses the accuracy of some of the model parameters, and later he discusses the accuracy of the models themselves.

The book would have been improved by a final chapter providing an evaluation of the state of the art of environmental modeling. In the reviewer's opinion it should have concluded that the "emperor has no clothes." The scientific community and the community of environmental regulators in government sorely need to be told the truth about models and the current lack of scientific certainty. It is disturbing that the trend toward premature promotion of modeling studies by environmental regulators—most recently for protecting groundwater resources—continues.

The greatest weakness of the book is the authors' unwillingness, or reluctance, to give strong evaluations of the models. Indeed, the only time they appear to be less than enthusiastic about models is when the models are of the simplest "black-box" variety, which require few data and give broad brush answers. These, in the eyes of the authors, should be avoided because they do not provide adequate description of the system. Yet, the more complex models in most cases only describe small parts of the problem in great detail. (If there are over 70 reactions in the production of photochemical smog, how do we know that a model that makes detailed representation of 19 reactions is better than a model that lumps them all together?)

In the end we model what we can model, and we cannot always model what needs to be modeled. Hence, the volume omits long-range transport of air pollutants, the acid rain phenomenon, and also omits the transport of chemicals through groundwater. These are examples of pressing environmental issues that the authors have not addressed. Yet, models that describe the transport of contaminants through groundwater systems do exist. But they too suffer from all the limitations common to the models discussed in the Basta and Bower book.

Peter P. Rogers is with Harvard University, Cambridge, MA 02138.

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Research Positions for Mathematical Physicists. Applications are invited for several research positions at the Center for Studies of Nonlinear Dynamics, La Jolla Institute, beginning summer 1983. Current research involves work on nonlinear wave-wave interactions, acoustic, optical, and radio wave propagation in random media, and fluctuation phenomena in the statistical mechanics of chemical and geophysical systems. Physicists and applied mathematicians who are interested in working on problems of the above type should send resumes and arrange for three letters of recommendation to be sent to Dr. Stanley Flatte, Director, CSND, La Jolla Institute, 8950 Villa La Jolla Drive, Suite 2150, La Jolla, California 92037.
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Professor Stanley N. Davis
Chairman, Search Committee
Department of Hydrology and Water Resources
University of Arizona
Tucson, Arizona 85721
602-621-3131.

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Successful applicants must have demonstrated an ability to conduct high-quality teaching and the potential to establish a productive research program in their area of specialty.

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Send a resume, brief description of teaching and research interests, transcripts and three letters of recommendation to:

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Department of Physical Sciences
Florida International University
Tamiami Trail, Miami, Florida 33199

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Send a resume and the names of three references familiar with the applicant's work to: D.A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-353-3527.

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Please send resume to: K.F. Klenk, Systems and Applied Sciences Corporation, 5809 Annapolis Road, Hyattsville, Maryland 20784, or call (301) 699-3954.

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University of Colorado, Boulder, Geochemist Position. Geochemist with active research program, stable isotopes, radioactive isotopes, and/or trace elements is being sought for a joint appointment in the Department of Geological Sciences and the Cooperative Institute for Research in Environmental Sciences (CIRES) of the University of Colorado.

The one-half time position within the Department of Geological Sciences is tenure track at the assistant or associate professor level with a starting salary of $12,000—$15,000 for the academic year.

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Applicants with experience, publications, and/or movable existing research equipment preferred. Preferred starting date would be January 1, 1984. Closing date for applications is October 1, 1983.

Applications should include statement of research and teaching interests, experience, a full vitae, and four letters of reference.

Apply to: Professor Charles Stern, Chairman, Geochemist Search Committee, Department of Geological Sciences, Campus Box 250, University of Colorado, Boulder, CO 80309.

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Temporary Faculty Position/UCLA. The Department of Earth and Space Sciences, UCLA, seeks applications for a temporary faculty position in the area of sedimentology, basin analysis, stratigraphy, and regional geology.

A Ph.D. or equivalent is required. There is no restriction as to the level. Duties will include undergraduate and graduate teaching, supervision of theses and dissertations, and development of a research program in the area of specialization. Field-based experience will be taken into consideration. The appointment will begin July 1, 1983, will be full-time nine-month, and will be renewable year-to-year. The department hopes to convert this position in 1984 or later, but has no assurance thereof. Send resume to:

Chairman
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405 Hilgard Avenue
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The Atmospheric Sciences Program at Georgia Tech is part of the School of Geophysical Sciences and is uniquely structured academically in that major emphasis is given to three areas of atmospheric sciences, namely, Dynamic Meteorology, Physical Meteorology, and Atmospheric Chemistry. Major research efforts in which students are currently involved include studies in wind and solar power, climate modification, air pollution, uses of satellite meteorology, measurements of aerosols in the atmosphere, modeling of planetary circulations, mesoscale and boundary layer dynamics, development of laser instrumentation for the detection of atmospheric aerosols and gases, global airborne measurements of atmospheric trace gases, photochemical and gas kinetic studies of atmospheric transformations, studies of biogeochemical cycles, and one-, two- and three-dimensional chemical and dynamic modeling of the troposhere and stratosphere.

Students interested in being involved in these or other exciting Atmospheric Sciences projects at Georgia Tech should write for information to:

Dr. Douglas D. Davis
School of Geophysical Sciences
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Application deadline is July 31, 1983. Later applications will be accepted if the position is not filled. Applications should include a complete resume, a statement of background and interests, copies of publications and names of at least three references. Applications should be sent to:

Bert E. Nordlie
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Dr. Larry G. Ward
Chairman, Search Committee
UMCEES
Horn Point Environmental Laboratories
P.O. Box 775
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Please contact: Dr. C.M. Scarle, Department of Geology, University of Alberta, Edmonton, Canada T6G 2E3, (403-432-2740) as soon as possible.

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Hydraulic Engineer, GS-810-11 or 12, at the USDA Sedimentation Laboratory, Oxford, Mississippi. Incumbent will develop computer methods for mathematically simulating runoff and sediment movement on intensively cropped agricultural land and study sediment losses from cropland having a range of typical soil, cropping, and topographic conditions at different rainstorm intensities and durations, using available experimental field data on erosion, runoff, and sediment size distributions. Must have expertise in hydraulics of runoff flow, sediment transport by water, and computer programming. This is a term appointment not to exceed 2 years. Salary ($26,959–$29,374 per annum) based upon qualifications and experience. This is a Federal Civil Service position. Applicants must be U.S. citizens. For application procedures, contact Vanessa Matthews, USDA, ARS, SRAO, HE-1, P.O. Box 53326, New Orleans, LA 70153. Telephone: (504) 589-4316.

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Send curriculum vitae and a list of three references to:

D. A. Gurnett
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Chairman—Department of Geological Sciences, Wright State University. The Department of Geological Sciences, invites applications for the position of chairman, to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

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Department of Geological Sciences
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Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Research Professor in Marine Geoscience/University of Rhode Island. The Graduate School of Oceanography invites applications for a research professorship in Marine Geoscience whose salary and rank are negotiable. Preference will be given to candidates who have clearly demonstrated abilities and interest in, but not necessarily limited to paleomagnetism. The position is funded by contracts and grants, however the research professor holds full faculty rights in addition to other benefits. The paleomagnetic facility at GSO is fully equipped, fully operational and oriented towards rapid measurement of large numbers of soft sedimentary samples. Applications are now open for the position which will become available about January 1, 1984.

Send letters of application, resume, and names and addresses of three professional references to: Roger L. Larson, Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island 02882.

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Physical Oceanography/University of Rhode Island. A postdoctoral research associate position is available starting October 1, 1983 for studies of tropical processes in the Pacific. The research involves the collection and analysis of data relating to the dynamic topography and zonal pressure gradients of the equatorial current systems as part of a long-term study of ocean influences on climate. Submit resume and professional references by August 15, 1983 to: Dr. D. Randolph Watts, Marine Research Associate II Position, UNIVERSITY OF RHODE ISLAND, P.O. Box 357, Kingston, Rhode Island 02881.

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University of Washington/Climate Dynamics Position. Possible opening for meteorologist with strong background in large scale dynamics and experience in use of dynamical models for long range prediction or climate simulation. Three quarter time research faculty (funded by research grants), one quarter time academic faculty (state funded). The successful candidate will lead a research project designed to explore the feasibility of dynamically based long-range weather prediction on time-scales of weeks to seasons. The project will be developed in collaboration with faculty members in the Department of Atmospheric Sciences. The position will involve a proportionate share of responsibility for teaching and supervising graduate students in the Atmospheric Sciences. Further information may be obtained by contacting the head of the search committee, Professor J.R. Holton. Telephone (206) 543-4010.

Applicants should send vita, description of research and teaching interests, and names of four references to:

Professor John M. Wallace, Chairman
Department of Atmospheric Sciences AK-40
University of Washington
Seattle, Washington 98195

Deadline for applications is July 31, 1983.

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Marine Research Associate II. Analyse and interpret time series of vertical acoustic travel time and bottom pressure. Prepare progress reports and scientific manuscripts on these results. Assist in planning experiments and participate in scientific cruises. Ph.D. in physical oceanography plus experience in computer programming with times series applications in FORTRAN. Submit application and resume by August 15, 1983, to: Dr. D.R. Watts, Marine Research Associate II Position, University of Rhode Island, P.O. Box 357, Kingston, Rhode Island 02881.

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Postdoctoral Position/Naval Postgraduate School. The Ocean Turbulence Laboratory has available a postdoctoral position for a person interested in the analysis and interpretation of oceanic turbulence data. The tenure is for one to two years. The successful candidate should have a Ph.D. in physical oceanography and although experience with turbulence data is preferable it is not essential. The opportunity for involvement in data gathering expeditions is also available.

Resumes can be sent to Dr. R.G. Lueck, Code 68Ly, Naval Postgraduate School, Monterey, CA 93940.

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Postdoctoral Position in Atmospheric Chemistry and/or Cloud Physics/Georgia Institute of Technology. Recent Ph.D. scientists interested in the development of theoretical models to study the chemistry and physics of precipitation are invited to apply to the Georgia Institute of Technology.

The salary is $18,000/year; period of appointment is one-two years. Applicants should send vita and statement of research interests and the names of two references to: Professor W.L. Chameides, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332.

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Howard University/Graduate Faculty Position. The Department of Geology/Geography invites applications for a tenure-track position in geochemistry at rank of assistant or associate professor beginning August 1983. Position involves development of graduate research program at Master's level. Desired specialization includes environmental geochemistry, geochronology, isotope geology. Send letter of application, resume and names of three references to Dr. David Schwartzman, Department of Geology/Geography, Howard University, D.C. 20059.

STUDENT OPPORTUNITIES

Graduate Assistantships/Howard University. Howard University in Washington, D.C., offers a new graduate program for the M.S. degree in geoscience; made possible by a grant from the Gulf Oil Company. Areas of specialization are field geology/geophysics, geochemistry, and meteorology/hydrology with remote sensing. Some stipends and assistantships are available. Potential students should write to Dr. Eric Christofferson, Department of Geology and Geography, Howard University, Washington, D.C. 20059.

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Meetings

Announcements

Caribbean Tectonics

A Symposium on Neotectonics, Seismicity, and Geologic Hazard in the Caribbean and Venezuela will be held October 23–28, 1983, in Caracas, Venezuela. The symposium will present new data concerning the tectonics of the Caribbean region, including seismological and geological data from Venezuela and the implications for Caribbean plate motions.

Among the topics to be covered are seismicity and present-day tectonics of the Caribbean; quaternary fault displacements and present fault activity; geothermal sources and fault activity; geodetic, geochronological, and geomorphological indicators of fault activity; and paleoseismicity, seismic morphogenesis, and geologic hazard. In addition, three field trips to portions of Venezuela will be offered.

For additional information contact André M. Singer P., Depto. Ciencias de la Tierra, FUNVISIS, Apartado Postal 1892, Caracas 101, Venezuela; telex: 26453.

The symposium, organized by the Venezuelan Foundation for Seismological Research (FUNVISIS) under the auspices of the 33rd Convention of the Venezuelan Association for the Advancement of Science (ASOVAC), is sponsored by the INQUA Neotectonics Commission.

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AGU

New AGU Mineral Physics Committee

A new Committee on Mineral Physics consisting of Orson Anderson (chairman), Peter Bell, Raymond Jeanloz, Robert Liebermann, Murli Manghnani, Alexandra Navrotsky, Tom Shankland, Joseph E. Smith, and Donald Weidner has been approved by the AGU Executive Committee.

The increasing number of research groups in an area that combines the study of mineral properties and solid state sciences (materials research) created the impetus for this new committee. At AGU meetings, mineral physics studies have been included in recent years in sessions of Volcanology, Petrology, and Geochemistry and sessions of Tectonophysics. A portion of the charter for the new committee includes arranging special sessions for mineral physics that would bridge the two sections.

The committee, appointed by AGU President James Van Allen, is now actively engaged in organizing plans to meet with section chairmen and to have topical conferences to provide a focus for mineral physics studies within AGU and the scientific community.

As yet, the discipline boundaries that fall under Mineral Physics are not settled; however, the following fields will be covered in the broadest sense: (1) physical measurements on minerals, (2) calorimetry, (3) high-pressure mineralogy, (4) defect structure studies, (5) mineral and solids equations of state, (6) quantum mechanics of solids, (7) spectral mineralogy, and (8) electrical measurements on minerals.—*PMB*

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation; the letter A denotes the Atmospheric Sciences section, which was formerly the Meteorology section.

Regular Member

Robert W. Adams, Magdy Ibrahim Amin (H), Brian D. Beckley (O), Teresa S. Bowers (V), Jean Burrus (O), Scott L. Davies (T), Roy K. Dokka (T), Robt L. Edwards (O), Virgil Allen Frizzell (V), Roger Hart (V), Michael M. Herron (V), Masahiko Honda, J. Michael Kelly (H), Philippe Lambert (P), William W. L. Lee (H), Chikao Nagasawa (A), Robert O. Pepin (P), Patricia A. Savage (V), Gordon E. Schacher (A), Timothy J. Shaw (O), Steve Slaff (V), Tammy King Walsh (O), Peter D. Welsh (H), Yuugping Zhang (H), Bao-Zhen Zhu (A),

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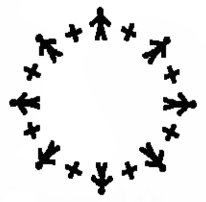

One thousand and twenty-eight new members have been elected through May 31, 1983. The top sponsors, AGU members sponsoring three or more new members, are listed below.

Eight Members Robert T. Hodgson.

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Nominations for Officers 1984–1986

The following nominees were presented by the Union and section nominating committees and were accepted by the Council:

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Peter S. Eagleson

General Secretary
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John D. Bossler Petr Vaníček	William E. Carter James Marsh
Geomagnetism/Paleomagnetism	
Subir K. Banerjee D. Ian Gough	John W. Hillhouse John L. LaBrecque
Hydrology	
Jacques W. Delleur Marshall E. Moss	Thomas Maddock III Edward A. McBean
Ocean Sciences	
Arnold L. Gordon Donald V. Hansen	Barbara Hickey William C. Patzert
Planetology	
Michael H. Carr Sean C. Solomon	Raymond E. Arvidson H. J. Melosh
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F. A. Dahlen Stewart W. Smith	William L. Ellsworth Emile A. Okal
Solar-Planetary Relationships	
R. A. Helliwell Martin Walt	
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Cosmic Rays	
	Leonard F. Burlaga Douglas Hamilton
Magnetospheric Physics	
	Mary Hudson George K. Parks
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Christopher H. Scholz Richard P. Von Herzen	Barry Parsons Wayne Thatcher
Volcanology, Geochemistry, and Petrology	
A. L. Boettcher Robin Brett	Gary E. Lofgren Bruce D. Marsh

Members of AGU are invited to submit additional nominees by petition in accordance with the bylaws. Each petition must be signed by at least 1% of the voting members of the Union or section, as the case may be, and such petitions must be received by the General Secretary by September 15, 1983. The number of names required to make a petition nomination is as follows: Union, 151; Geodesy, 6; Geomagnetism and Paleomagnetism, 7; Hydrology, 26; Atmospheric Sciences, 11; Ocean Sciences, 21; Planetology, 7; Seismology, 15; Solar-Planetary Relationships, 18; Tectonophysics, 15; and Volcanology, Geochemistry, and Petrology, 16.

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(L) ☐ LIFE MEMBERSHIP. A single payment (currently $300) is acceptable in lieu of annual dues. Privileges accorded are those granted to all members and have been changed from time to time.

PUBLICATIONS

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					Journal of Geophysical Research is published in three monthly sections:
$42	$19	$18	☐	☐	Space Physics, Section A (blue) Bengt Sonnerup, Editor, 2800 pages anticipated for 1983.
$48	$26	$21	☐	☐	Solid Earth and Planets, Section B (red) Gerald Schubert, Editor, 5500 pages anticipated for 1983.
$38	$21	$18	☐	☐	Oceans and Atmospheres, Section C (green) Ralph Cicerone, Editor, Atmospheric Chemistry and Aeronomy; A.O. Kirwan, Jr., Editor, Oceanography and Boundary Layer Meteorology. Members may subscribe to the full section or to either half of JGR Green published in alternate months for half the subscription price. 3200 pages anticipated for 1983.
$18	$11	$8	☐	☐	Atmospheric (only)
$18	$11	$9	☐	☐	Oceanography (only)
$40	$20	$6	☐	☐	Water Resources Research Published six times a year. Recognized as the leading journal in the water sciences (containing both natural and social sciences). Jared Cohon and Stephen J. Burges, Coeditors, 1200 pages anticipated for 1983.
$45	$23	$10	☐	☐	Reviews of Geophysics and Space Physics An important addition to each geophysicist's permanent library; Andrew Nagy, Editor, 2300 pages anticipated for 1983.
$22	$20	$5	☐	☐	Geophysical Research Letters Reaches more members than any other AGU publication except EOS; monthly reports of fast moving areas of research. Douglas G. Torr and R. E. Alecker, Coeditors, 1200 pages anticipated for 1983.
$33	$27	$8	☐	☐	Radio Science Published six times a year. Akira Ishimaru, Editor, 1100 pages anticipated for 1983.
$22	$11	$4	☐	☐	Tectonics Published bi-monthly. The newest addition to AGU's family of prestigious journals, Tectonics is devoted to publishing leading papers in the structure and evolution of the terrestrial lithosphere, integrative tectonics, structural geology, and materials science. Editor, John F. Dewey, 600 pages anticipated for 1983.

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Exploration Geophysics

0910 Magnetic and electrical methods
THREE-DIMENSIONAL MODEL OF THE KOYNA AREA OF MAHARASHTRA STATE (INDIA) BASED ON THE SPECTRAL ANALYSIS OF AEROMAGNETIC DATA
J.G. Negi (Theoretical Geophysics Group, National Geophysical Research Institute, Uppal Road, Hyderabad 500 007, India) P.K. Agrawal, and N.G.K. Rao

The estimation of thickness of trap rocks in the earthquake-affected Koyna area is an important parameter for revealing the topography that existed before the Deccan volcanism. In the present work, a new technique is proposed for delineating a three-dimensional block model for the Koyna area by the spectral analysis of aeromagnetic data. The thickness in the area was found to vary from 700 to 1200 m, which correlates well with the results of other geophysical investigations.
GEOPHYSICS, VOL. 48, NO. 7

0995 General or miscellaneous
ELLIPTICAL ANISOTROPY—ITS SIGNIFICANCE AND MEANING
K. Helbig (Instituut voor Aardwetenschappen, Budapestlaan 4, Postbus 80.021, 3508 TA Utrecht, The Netherlands)

Wavefronts in anisotropic media are often assumed to be approximately elliptical. However, in transversely isotropic media only the wavefront of SH waves is always an oblate ellipsoid. The wavefront of SV waves is never an ellipsoid, and the wavefront of P waves is an oblate ellipsoid if and only if the expression $(C_{11}-C_{44})(C_{33}-C_{44})-(C_{13}+C_{44})^2$ vanishes. This cannot happen if the anisotropy is due to lamination (periodic layering with a spatial period small in comparison to the wavelength).

The occurrence of elliptical wavefronts cannot be detected on the basis of surface observations of times alone, since the complete wave field can be transformed into one with spherical wavefronts everywhere by simple stretching of layers. Neither arrival times nor apparent slownesses (and thus Snell's law) are affected by this transformation. All concepts and algorithms applicable to spherical wavefronts are applicable to elliptical wavefronts, in particular the determination of a velocity as the zero-offset limit of the stacking velocity. Since the resulting velocity is invariant under the stretching transformation, it can represent only a velocity that is itself an invariant, viz., the velocity at right angles to the direction of stretching. However, explicit observations of SH waves give an independent indication of elliptical anisotropy.

Although the wavefronts of P and SV waves can never be ellipsoids if the anisotropy is the result of lamination, pieces of the wavefront can be represented with sufficient accuracy by an ellipsoid. This representation allows a simple determination of the ratio "zero-offset limit of stacking velocity/vertical velocity." Constraints on the parameters of the thin layers that constitute a laminated medium can be translated into constraints of the above velocity ratio. For P waves this ratio is centered around unity for a wide range of constituent parameters.
GEOPHYSICS, VOL. 48, NO. 7

Hydrology

2133 Groundwater (irrigation)
A MATHEMATICAL MODEL FOR BORDER STRIP IRRIGATION
G. J. Weir (Applied Mathematics Division, DSIR, P. O. Box 1335, Wellington, New Zealand).

A kinematic wave model is developed to discuss surface irrigation when the infiltration function consists of a long time gravity term plus a discontinuous short time capillary or sorptivity term. The corresponding model equations are solved exactly for the depletion, recession and advance phases until the arrival of the depletion characteristic at the check, but thereafter a numerical approach was needed. The kinematic wave solution is used to derive a condition for the validity of the corresponding Lewis-Milne problem, and using the shallow water equations a condition is derived for the validity of our kinematic wave solution. The kinematic wave solution is determined by three non-dimensional parameters whose influence is displayed graphically. (Irrigation, border strip, kinematic wave).
Water Resour. Res., Paper 3W0785

2150 Precipitation
TIMING AND DURATION OF HIGH RAINFALL RATES IN THE SOUTHWESTERN UNITED STATES
Herbert B. Osborn (USDA-ARS, Southwest Rangeland Watershed Research Center, Tucson, AZ. 85719)

High intensity rains of short duration and limited areal extent are important in the southwestern United States to engineers, hydrologists, meteorologists, and others concerned with the frequency, magnitude, duration, and distribution of thunderstorm rainfall. Data from two dense raingage networks, one in southeastern Arizona and the other in eastern New Mexico, were used to establish expected occurrences of high rainfall rates (50 mm/hr) and diurnal and seasonal variability in such occurrences. Expected occurrences and durations above various thresholds were determined for both point and area for each location.
Water Resour. Res., Paper 3W0781

2180 Water Quality
AN ANALYSIS OF DISSOLVED OXYGEN CONCENTRATIONS IN TAILWATERS OF HYDROELECTRIC DAMS AND THE IMPLICATIONS FOR SMALL-SCALE HYDROPOWER DEVELOPMENT
G. F. Cada, K. D. Kumar, J. A. Solomon and S. G. Hildebrand (Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830)

One of the environmental issues affecting small-scale hydropower development in the United States is water quality degradation. The extent of this potential problem, as exemplified by low dissolved oxygen concentrations in reservoir tailwaters, was analyzed by pairing operating hydroelectric sites with dissolved oxygen measurements from nearby downstream U.S. Geological Survey water quality stations. These data were used to calculate probabilities of noncompliance (PNCs), i.e., the probabilities that dissolved oxygen concentrations in the discharge waters of operating hydroelectric dams will drop below 5 mg/L. The continental states were grouped into eight regions based on geographic and climatic similarities. Most regions had higher mean PNCs in summer than in winter, and summer PNCs were greater for large-scale than for small-scale hydropower facilities. Cumulative probability distributions of PNC also indicated that low dissolved oxygen concentrations in the tailwaters of operating hydroelectric dams are phenomena largely confined to sites with large-scale facilities. (Dissolved oxygen, hydroelectric power).
Water Resour. Res., Paper 3W0606

Meteorology

3720 Climatology
REFLECTANCE CHARACTERISTICS OF UNIFORM EARTH AND CLOUD SURFACES DERIVED FROM NIMBUS-7 ERB
V. R. Taylor (NOAA/National Earth Satellite Data and Information Service, Washington D. C., 20233) and L. L. Stowe

Data from the scanning channels of the Nimbus-7 Earth Radiation Budget (ERB) experiment are combined with other data on Earth surface conditions and cloudiness. Patterns of bi-directional reflectance are constructed from this data for uniform Earth and cloud surfaces. Examples are shown that illustrate the bi-directional properties of surfaces and how these vary with solar zenith angle (SZA). Dependence of albedo on SZA is also shown.

Conclusions may be summarized as follows: (1) Water surfaces exhibit limb brightening at all SZAs; (2) Cloud and land surfaces change from limb darkening to brightening as SZA increases; (3) The land surface exhibits higher backward reflection for SZAs less than about 50°; (4) All of the surfaces in this study become more specular as SZA increases; (5) Snow is the most nearly isotropic of these surfaces; (6) Snow albedo shows very little variation with SZA and even shows a slight decrease over a limited range; (7) Albedo generally increases with increasing SZA for other than snow surfaces; (8) Angular patterns for high water and ice clouds are quite similar, but ice clouds are more nearly isotropic; (9) The angular patterns developed in this study are in qualitative agreement with those from other investigations. (Bi-directional reflectance, albedo, radiation budget).
J. Geophys. Res., Green, Paper 3C0025

3750 Interaction of atmosphere with electromagnetic waves
ASSESSMENT OF THE CONTRIBUTION OF DIFFERENTIAL POLARIZATION TO IMPROVED RAINFALL MEASUREMENTS
C.W. Ulbrich (Clemson University, Clemson, S.C. 29631) and D. Atlas

A description is given of the effects of variations in the shape or breadth of the drop size distribution (DSD) on rainfall parameters deduced from a measurement technique which employs the differential reflectivity factor Z_{DR} and the reflectivity factor at horizontal polarization Z_H. The mathematical form of the DSD used is a gamma distribution. Justification for such a form is given through consideration of varying DSD shape in nature as implied by the results of empirical analyses of other workers. Theoretical expressions are derived for rainfall rate R, liquid water content W, and median volume diameter D_0 in terms of Z_{DR}, Z_H and size distribution dependent factors. These expressions are used to assess quantitatively the effects of changes in DSD breadth on values of R, W and D_0 deduced from Z_{DR} and Z_H. They are also used to show the effects of measurement errors in Z_{DR} and Z_H on R, W and D_0. The potential improvement in accuracy which is possible when account is taken of DSD shape variations is shown by simulating (Z_{DR}, Z_H) dual-measurement method using experimental raindrop size spectra. Methods by which DSD shape variations could be detected through the use of a third remote measurable are discussed.
Rad. Sci., Paper 3S0813

3799 General (Solar-terrestrial Relationships)
COMMENTS ON "EVIDENCE FOR A SOLAR CYCLE SIGNAL IN TROPOSPHERIC WINDS"
O. E. Yoos (Control Data Corporation, P.O. Box 1249, Minneapolis, MN 55440), G. D. Nastrom and A. D. Belmont

In a previous paper it was suggested that a substantial 11-year period solar cycle influence may exist in tropospheric wind and temperature data. The current study reanalyzes a subset of the original data with the intent of better assessing the significance of the reported correlations. Extensive use is made of empirical testing; also employed is a maximum entropy spectral analysis. The new findings indicate that the correlations between the 10.7 cm solar flux and 300 mb winter winds are not statistically significant. An upper limit on the percentage of variance in these winds which is explainable by a solar cycle influence is suggested to be ~6%. (Solar-terrestrial, climatology)
J. Geophys. Res., Green, Paper 3C0796

Oceanography

4708 Boundary Layer
EFFECTS OF TIME-VARYING VISCOSITY ON OSCILLATORY TURBULENT CHANNEL FLOW
J. W. Lavelle (NOAA/Pacific Marine Environmental Lab., 3711 15th Ave. N.E., Seattle, WA 98105), H. O. Mofjeld

A semi-analytic model of a time-dependent bottom boundary layer has been constructed in which flow and time-variable eddy viscosity are interdependent. Evaluated in the case of oscillatory forcing at tidal frequencies, the model shows that neglecting time-variations in viscosity results in underestimates of maximum bottom stress and distortion of the flow profile near times of flow reversal. Acceleration and variable viscosity also add terms proportional to $\sin(z/z_0)$ and z to the conventional steady-state $\ln(z/z_0)$ profile near the bottom. Inferences based on the logarithmic profile for measurements made in time-dependent boundary layers may consequently yield inaccurate estimates of roughness length and friction velocity. Stress is seen to lag flow at points away from the bottom, as has been observed [illegible], though bottom stress always leads flow aloft. Bottom stress is found to depend linearly on the free-stream velocity in the limit of time-invariant viscosity. In the limit of strongly time-varying viscosity, bottom stress is more nearly quadratic. The friction coefficients are reasonably time-independent only when the phase lead, θ, between bottom stress, τ_B, and free-stream velocity, U, is incorporated into the bottom friction expression. A generalized bottom drag law for oscillatory flow encompassing all these features takes the form $\tau_B = a_\beta [U(t/T+\theta)]^\beta\, U(t/T+\theta)$, where β has a value between 0 and 1, and θ is typically a few tens of degrees. In the examples evaluated, when β = 0, a_0 (conventionally called r) ranges from 1-15 × 10^{-2} cm/s, and when β = 1, a_1 (conventionally called C_D) ranges from 1-5 × 10^{-3}, the variation in both cases depending on surface Rossby number. (Oscillatory boundary layer, tidal flow, bottom friction, flow profiles).
J. Geophys. Res., Green, Paper 3C0704

4760 Sea Ice (Emissivity)
SEA ICE EFFECTIVE MICROWAVE EMISSIVITIES FROM SATELLITE PASSIVE MICROWAVE AND INFRARED OBSERVATIONS
J.C. Comiso (Goddard Laboratory for Atmospheric Sciences, NASA/Goddard Space Flight Center, Greenbelt, MD 20771)

Microwave sea ice emissivities are investigated on a global scale using near simultaneous images from the dual-polarization Scanning Multichannel Microwave Radiometer (SMMR) and the Temperature Humidity Infrared Radiometer (THIR), both on board the Nimbus-7 satellite. The emissivities in several study areas in the Arctic region are observed to be approximately constant during a nine-month period within the fall, winter, and spring months, for both first year and multiyear ice, with a standard deviation of about 3%. During the onset of summer, when the snow cover starts to melt, increases of about 30% in emissivities are observed at 37 GHz for multiyear ice with the effect decreasing to less than 6% at the 6.6 GHz channels. Multichannel cluster analysis over very large study areas during winter shows considerable variability in emissivities of well-defined clusters of consolidated ice at 37 GHz and about one-third as much at 18 GHz. Some nonlinearities in the functional relationship of the emissivities in the consolidated ice regions between first-year and multiyear ice are also evident, especially when data from one frequency is plotted against that of another. However, the cluster analysis technique separates the various emissivity data points into distinct clusters corresponding to radiometrically different ice types. If the variability within each cluster is quantified and taken into account using multispectral analysis, in addition to improving the capability of classifying ice by age, information about ice thickness and surface characteristics might also be obtainable. (Sea ice, emissivity, SMMR, THIR).
J. Geophys. Res., Green, Paper 3C0668

4705 Surface waves
SHORT WAVES ON LONG WAVES
K. Kenyon (Scripps Institution of Oceanography, A-010, University of California, San Diego, La Jolla, California, 92093), D. Sheres and R. Bernstein

Spatial changes in the wave length and direction of short wave length surface gravity waves, caused by their interaction with much longer wave length gravity waves, are calculated by applying geometrical optics to the short waves in the reference frame that reduces the long waves to a steady current, which is horizontally variable but unidirectional. The wave rays are very nearly parallel to the direction of the current. Along a ray the wave length and the angle between the propagation direction of the short waves and the ray direction are both maximum at the long wave troughs (where the steady current speed is maximum) and minimum at the crests (where the current speed is minimum), whether the short waves travel with or against the long waves. The short waves can never be reflected by the long waves. The magnitudes of the wave length and direction changes of the short waves calculated are valid for arbitrary surface slope of both short and long waves, assuming no wave breaking occurs. Therefore, these results are more general than any known ones, but they agree with earlier work when all wave slopes are taken small compared to unity and the wave number directions of the short and long waves are parallel. (Wave-wave interaction, geometrical optics, finite amplitude).
J. Geophys. Res., Green, Paper 3C0715

4770 Turbulence and diffusion
OCEANIC TURBULENCE: BIG BANGS OR CONTINUOUS CREATION
D. R. Caldwell (School of Oceanography, Oregon State University, Corvallis, Oregon, 97331)

In a discussion of the turbulence characteristics of patches of "microstructure" in the ocean, the hypothesis advocated by Gibson (1980), that the patches are produced by very rare but extremely powerful turbulence-generating events which usually have "fossilized" before their observation, is contrasted with the hypothesis of a turbulence field driven at the time and scale at which it is observed. In this "continuous-creation" notion, by no means original here, the driving energy is converted to turbulence kinetic energy in such a way that the observed overturning thickness scale, L_T, is linearly related to the length scale $(\varepsilon/N^3)^{1/2}$, where ε is the kinetic-energy dissipation rate and N is the buoyancy frequency. (This relationship does not hold in boundary layers, where another length scale, the distance from the boundary, is imposed.) If the time scale of the largest vertical eddies is N^{-1}, the parameters of turbulence and its effects can be estimated by the measurement of ε and L_T. For example the kinetic energy dissipation rate would be proportional to $L_T^2N^3$ and the vertical eddy diffusivity would be proportional to L_T^2N. Careful attention must be paid to the sampling process and its assumptions. "Fossilized" regions are expected, in the sense that these regions had previously been the sites of stronger turbulence than is observed at the time of observation, but consideration of the fossilization process is not necessary for the interpretation of microstructure data.
J. Geophys. Res., Green, Paper 3C0714

Particles and Fields—Ionosphere

5560 Particle precipitation
WHISTLER INDUCED CHARGED PARTICLE PRECIPITATION AND DISTORTION OF GEOMAGNETIC FIELD
R.P. Singh (Applied Physics Section, Institute of Technology, Banaras Hindu University, Varanasi 221005, India) and R. Prasad

The geomagnetic field is invariably distorted because of the interaction with the solar wind. The magnitude and morphology of geomagnetic field distortion changes with the solar wind velocity, solar particle flux, magnitude and direction of frozen-in interplanetary magnetic field. Effect of these distortions in the geomagnetic field on whistler wave interaction with energetic charged particles has been studied. Precipitated charged particle influx has been found to increase with enhanced geomagnetic field distortions. It is envisaged that the changes in precipitated electron influx might carry the signatures of geomagnetic field distortions. The morphological features of precipitated charged particles, auroral display, bremsstrahlung flux and optical emissions may be interpreted with the changes in the solar wind interaction with geomagnetic field and its day to day variations. (electron precipitation, wave-particle interaction, pitch angle scattering, geomagnetic field distortion).
J. Geophys. Res., Blue, Paper 3A0721

5580 Wave propagation
STANDING WAVE PATTERNS IN VLF HISS
R. Brittain (School of Electrical Engineering, Cornell University, Ithaca, New York, 14853), P. M. Kintner, M. C. Kelley, J. C. Siren, and D. L. Carpenter

Observations have been made of systematic patterns in VLF hiss, which can be interpreted as a standing wave pattern formed by reflection in the lower ionosphere. Multicomponent VLF electric and magnetic field experiments were flown on three sounding rockets (Nike-Tomahawk 18.203-205) from Siple station, Antarctica during December 1980-January 1981. One feature of the natural emissions was observed in a very similar form during each flight. A band of hiss, typically from 1.5-3 kHz, was seen on the upleg to form a series of closely spaced stripes with whistler-like dispersion. These first appeared at an altitude of 90-95 km and extended for as much as 40 km in altitude. On the downleg the stripes were observed at the same altitude with the pattern reversed in time. No such patterns were observed by the VLF receivers operating at the same time on the ground at Siple or at its conjugate point. It is suggested that the patterns are interference effects due to downcoming waves reflecting from a layer in the E-region and forming a standing wave pattern. The observed stripes are then due to the rocket traversing the standing wave pattern in opposite directions on upleg and downleg. If this interpretation is correct, the fringe spacing should be related to the wavelength and permits a calculation of the refractive index. In one example we calculate n=43.7 in good agreement with two independent determinations of the refractive index. (VLF hiss, standing waves).
J. Geophys. Res., Blue, Paper 3A0807

Particles and Fields—Magnetosphere

5720 Interactions between solar wind and magnetosphere
NUMERICAL SIMULATION OF THE DAYSIDE RECONNECTION
M. Hoshino (Institute of Space and Astronautical Science, Komaba, Meguro, Tokyo 153, Japan) and A. Nishida

To examine the basic characteristics of reconnection on the dayside magnetopause, we have numerically studied the reconnection process at an interface where the total pressure is in balance but the thermal pressure is higher on one side than on the other. Reconnection is caused by anomalous resistivity that is assumed to operate only in a localized region at the interface. Boundaries are assumed to be free boundaries but reflection of the perturbations originating from inside the simulation region is suppressed by placing an absorbing region. Results can be expressed as follows, denoting the high pressure and low pressure regions as magnetosheath and magnetosphere, respectively. (1) A slow shock is formed in magnetosheath and a slow expansion fan is formed in magnetosphere. (2) At the slow shock the Lorentz force and pressure gradient are of comparable importance in accelerating plasma, but at the expansion fan the pressure gradient has the dominant effect. (3) The acceleration depends on the direction of the Interplanetary Magnetic Field (IMF) and when the reconnection line is assumed to be directed at the half angle ($\frac{\psi}{2}$) between IMF and geomagnetic field, the velocity of the accelerated plasma is roughly proportional to $\sin^2(\frac{\psi}{2}) + \sin^3(\frac{\psi}{2})$. (magnetopause, magnetosphere, reconnection, slow expansion, slow shock).
J. Geophys. Res., Blue, Paper 3A0800

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5720 (Interactions between solar wind and magnetosphere)
AN ISEE-3 HIGH TIME RESOLUTION STUDY OF INTERPLANETARY PARAMETER CORRELATIONS WITH MAGNETOSPHERIC ACTIVITY
D. N. Baker (Los Alamos National Laboratory, Los Alamos, NM 87545), R. D. Zwickl, S. J. Bame, E. W. Hones, Jr., B. T. Tsurutani, E. J. Smith, and S.-I. Akasofu

From 1978 to 1982 the ISEE-3 spacecraft was in a "halo" orbit around the sun-earth Lagrangian point, L_1, approximately 240 R_E upstream of the earth and was continuously in the upstream solar wind. In order to evaluate the efficacy of such a spacecraft as a real-time interplanetary monitor to predict substorm activity and to measure solar wind energy input into the terrestrial magnetosphere, three periods in 1978 were selected in which to perform detailed correlation analyses between solar wind and interplanetary magnetic field (IMF) parameters and magnetospheric activity indices such as AE and Dst. High-time resolution (1-min) averages of combined solar wind parameters and IMF parameters were used to perform linear cross-correlation analyses with the similarly averaged magnetospheric activity indices. A significant dependence of these results on levels of activity is found. During relatively quiet conditions all tested parameters (ε, VB_s, V^2B_s) produce high (0.7–0.8), nearly identical linear correlation coefficients with AE. During disturbed times substantially lower correlations between all parameters and AE are found (r ≲ 0.6 for VB_s, r ≲ 0.4 for ε). A measure of total magnetospheric energy dissipation (U_T) involving both auroral and ring current terms is useful and can be meaningfully calculated during disturbed periods of geomagnetic storm (or substorm) activity. U_T is rather highly correlated (r > 0.6) with all tested parameters during disturbed times. The parameter ε is often superior to the B_s parameters in prediction of U_T. Notably, we find that the typical intrinsic 15-40 minute delay between interplanetary parameters and magnetospheric response during quiet periods diminishes to ≲ 15 minutes during disturbed times. (Geomagnetic activity, solar wind coupling).
J. Geophys. Res., Blue, Paper 3A0718

5733 Magnetic storms
PARTICLE AND WAVE DYNAMICS DURING PLASMA INJECTIONS
H. C. Koons (Space Sciences Laboratory, The Aerospace Corporation, P. O. Box [illegible], Los Angeles, California, 90009), J. F. Fennell

The SCATHA satellite measures particle and wave parameters as it moves earthward on the dusk side from the plasmasphere into the plasma sheet. In many cases plasma waves are not observed in the quiescent plasma sheet prior to a plasma injection. The electron distribution function prior to entry into the plasma sheet is a nearly isotropic soft spectrum, J(E) ~ 1/E. Just inside the plasma sheet the spectrum begins to harden and becomes anisotropic, $J_\perp > J_\parallel$. As the satellite penetrates deeper into the plasma sheet the spectrum further hardens, especially near α_o ~ 90°. At the injection the electron spectrum dramatically hardens and often becomes peaked in the keV energy range. The pitch angle anisotropy is further enhanced in favor of $J_\perp$. The plasma wave emissions onset occurred at the time of the injection. Whistler-mode waves are observed below the electron cyclotron frequency. Electrostatic waves are detected in bands between the electron cyclotron frequency harmonics.
J. Geophys. Res., Blue, Paper 3A0771

5760 Convection
SELF-CONSISTENT THEORY OF THREE-DIMENSIONAL CONVECTION IN THE GEOMAGNETIC TAIL
J. Birn and K. Schindler (Theoretische Physik IV, Ruhr-Universität Bochum, 4630 Bochum, F.R.G.)

The self-consistent theory of time-dependent convection in the earth's magnetotail of Schindler and Birn (1982) is extended to three dimensions to include more realistic tail geometry and three-dimensional flow. We confirm, that a steady state solution implies unrealistic tail geometry or large particle energy losses that are unrealistic during quiet times and conclude therefore as in the 2-D case that the magnetotail becomes time-dependent for typical convection electric fields. Explicit solutions are derived, even analytically, for the three-dimensional flow and the electric and magnetic field in a realistic tail geometry and quantitative examples are presented. Consequences of time-dependent convection are demonstrated considering two idealized cases of magnetospheric response to solar wind changes, (A) uniform compression as the likely consequences of increasing (static, dynamic or magnetic) solar wind pressure, and (B) compression only in the z-direction perpendicular to the plasma sheet as the probable consequence of a dawn to dusk external electric field (E_y > 0) corresponding to a southward interplanetary magnetic field component (B_z < 0). It is found that in case (A) the stability properties do not change very much in time while case (B) leads to an evolution toward instability, consistent with the observed correlation of B_z < 0 or E_y > 0 with geomagnetic activity. Several other features, already presented in the 1-D theory, are confirmed.
J. Geophys. Res., Blue, Paper 3A0742